	Particle Physics Division Mechanical Department

Engineering note number:		Date:	03/02/2005

Experiment	FLARE
Project	Inner tank
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Reviewer(s)	
Abstract	Preliminary FEA of the FLARE inner tank with thick wall.

1. Objective

The goal of this analysis is to gauge - very roughly- the need for reinforcements at the top of the tank wall in respect to the lateral load applied by the wires. The hydrostatic load was not considered since it would mask the effect of the load considered. The wall was simplistically assumed to be 2" thick for the half bottom and 1" thick for the half top. The point loads were also not spread over a more realistic are but applied to one single node.

2. Allowable Stresses

The criterion adopted in this note is:

Stress intensity (2 x maximum shear stress)

shall be smaller than

23.7 ksi (*)

(*) Refer to CB&I documentation (which is based on ASME) – see below.

Note: welds considered to be full penetration, visually inspected and U.T. tested as to allow 100% efficiency.

...ost metals increase in strength with a decrease in temperature. Some, however, such as carbon steel, suffer an almost complete loss of ductility at low temperatures, making them useless for cryogenic vessel construction. Copper, nickel, aluminum and most alloys of these metals exhibit no ductile to brittle transitions and, therefore, are suitable for cryogenic service. Stainless steel of the 18 per cent chrome, 8 per cent nickel classification also exhibits excellent ductility.

Certain minimum requirements have been established by the ASME Code, API Standard 620 and regulatory bodies in the construction of vessels for ultra-low temperatures.

MATERIALS FOR CRYOGENIC TANKS (THROUGH -450°F)

ALLOWABLE STRESS (PSI)

Material	Designation Number	Pressure Storage (ASME)	Flat-Bottom Storage Tanks CB&I Design Methods
Stainless	A240 Type 304	18,750	22,500
Aluminum	AA5052 AA5086 AA5083	6,250 8,700 10,000	7,100 10,500 13,300
5% Nickel 5% Nickel 9% Nickel	A 645 — A553 Class 1 A353	23,700 23,750	31,700 31,700 31,700

STRESS INTENSITY = 23,700 => MAX. SHEAR = 11,850 PSI

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Tank Shells and Insulation

Refrigerated storage tanks and their insulation systems must be designed to work together to assure optimum performance. Low temperature insulation is required for both spherical and flat bottom cylindrical refrigerated storage tanks.

There are three principal types of shell and insulation systems for refrigerated gases: single steel wall (SW), double steel wall (DW), and concrete outer shell with double steel wall interior. Common to both the SW and DW insulation systems is the suspended deck roof insulation system that CB&I introduced in 1966 and load bearing bottom insulation systems. The following portions of this section describe DW, SW, suspended deck roof, and load bearing bottom insulation systems, and the concrete outer shell tanks in more detail.

3. Parameters Used

Program: I-DEAS 11 NX m2 / Simulation.
Analysis: Linear Static,
Material properties -   9%Ni steel:
density $= 7.32986 \times 10^{-4}$ lbf.sec^2/in^4
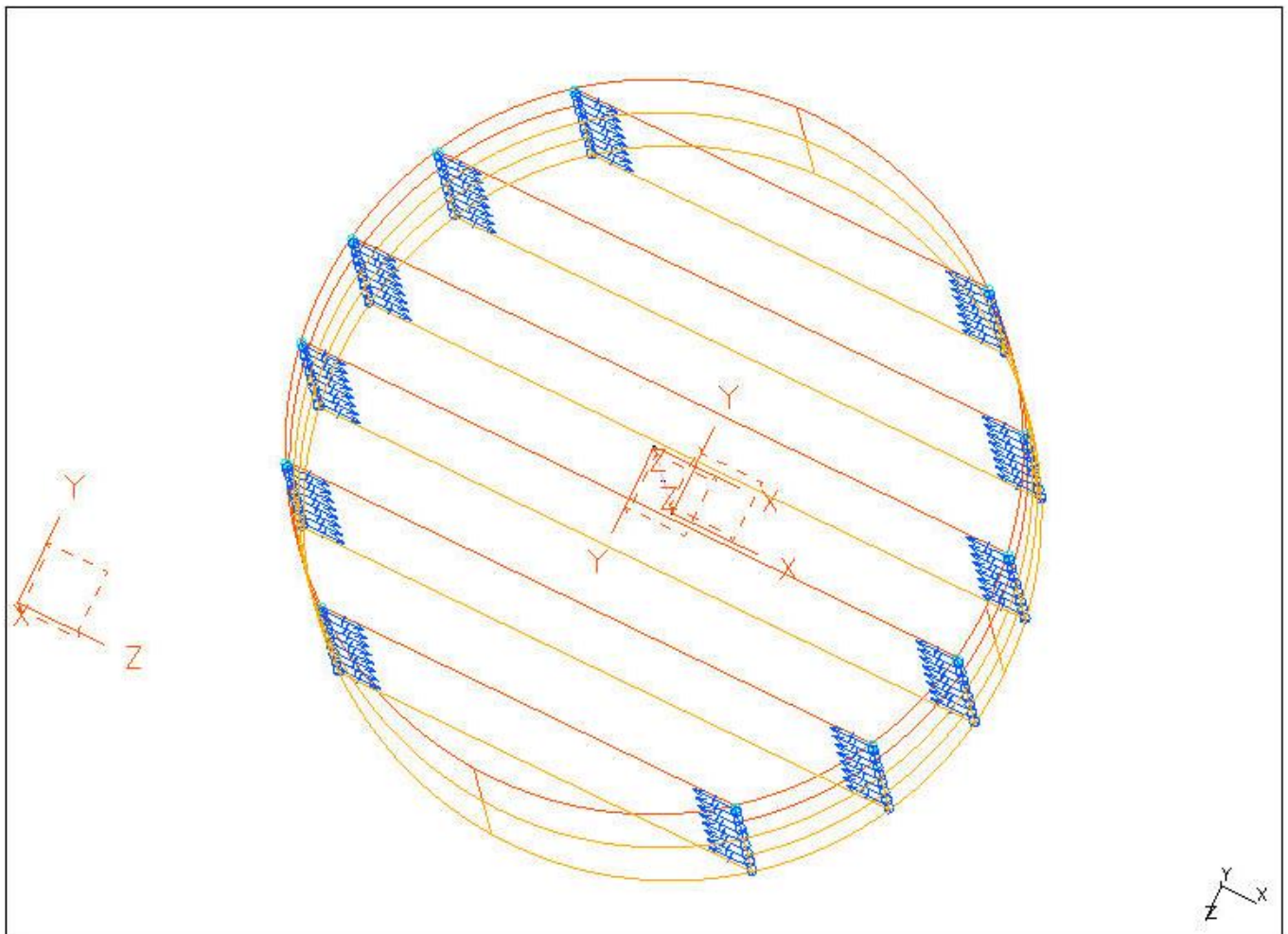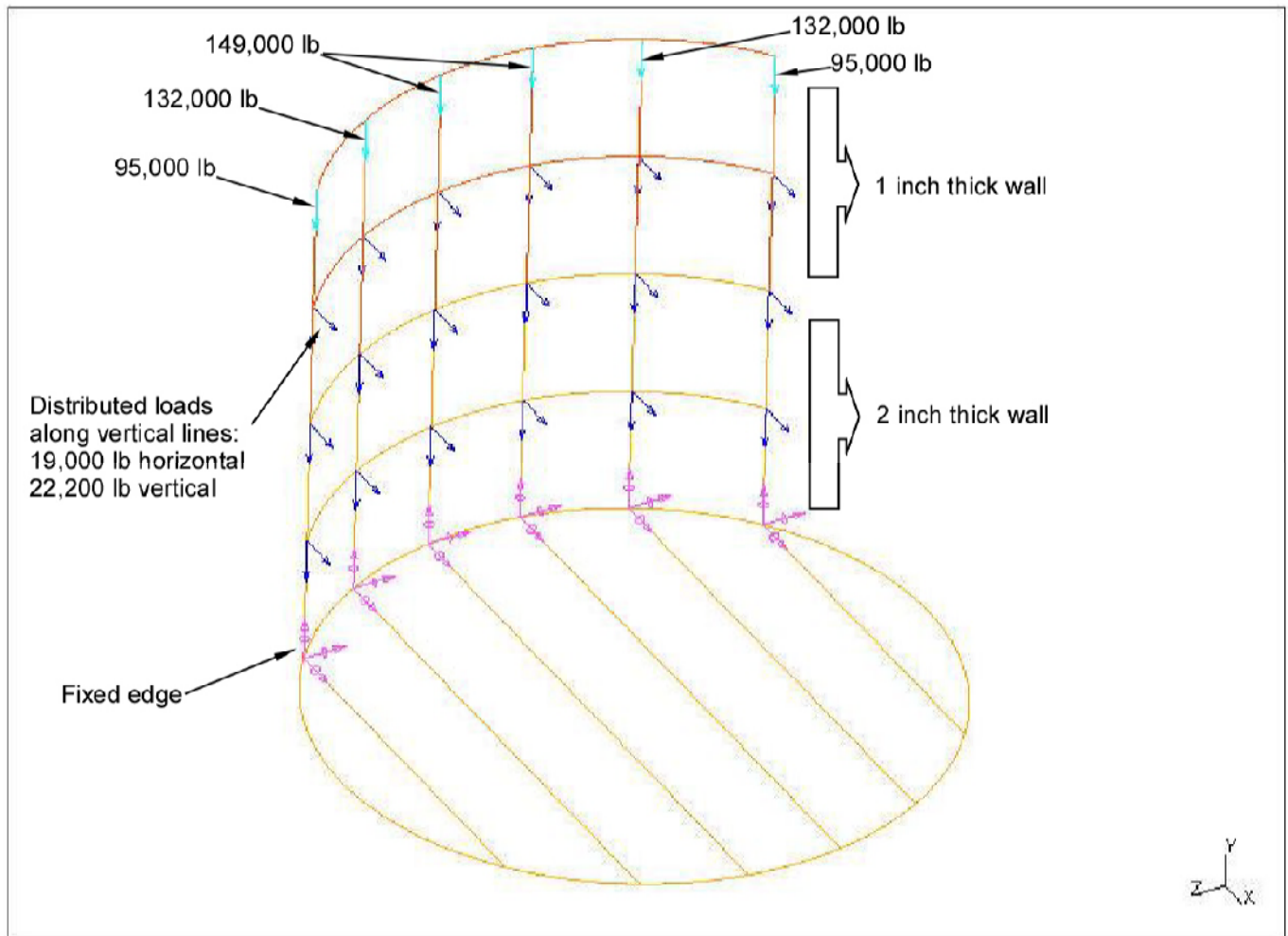η   = 0.3
E $= 2.88 \times 10^7$ psi
Elements: thin shell parabolic quadrilateral, average mesh size about 24', 2" thick for the half bottom and 1" thick for the top.

4. Boundary Conditions

Bottom of walls is fixed in translations. Load is applied according to what is shown below. Gravity is also applied.

Figure labels:
- 149,000 lb
- 132,000 lb
- 132,000 lb
- 95,000 lb
- 95,000 lb
- 1 inch thick wall
- 2 inch thick wall
- Distributed loads along vertical lines: 19,000 lb horizontal 22,200 lb vertical
- Fixed edge

5. Results

The difference between the results averaging the stresses across elements and not averaging is significant, indicating that the mesh needs refinement. However, for the purpose of this note, these two results are presented and they should be taken as upper and lower brackets for the an accurate solution, which should then rely in between these values.

As can be seen in the plots below , the results are acceptable: **stress intensity is 17.2 ksi**, and maximum deformation is 0.21", in the worst case scenario That indicates that, with the wall thicknesses used in this analysis, and if the bottom is braced appropriately and not allowed to move inwards, the walls would be fine, without additional need of lateral bracing. However, further and more detailed analysis is required.

Note that the higher stresses happen at the top, where the plate thickness is 1/2" only.

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RESULTS: 3- B.C. 1,STRESS_3,LOAD SET 1
STRESS - MAX SHEAR MIN: 1.46E+01 MAX: 6.36E+03
DEFORMATION: 1- B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.07E-01
FRAME OF REF: PART

VALUE OPTION:ACTUAL
SHELL SURFACE: TOP

6.36D+03
5.72D+03
5.09D+03
4.45D+03
3.82D+03
3.19D+03
2.55D+03
1.92D+03
1.28D+03
6.49D+02
1.46D+01

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RESULTS: 3- B.C. 1,STRESS_3,LOAD SET 1
STRESS - MAX SHEAR MIN: 1.34E+01 MAX: 8.51E+03
DEFORMATION: 1- B.C. 1,DISPLACEMENT_1,LOAD SET 1
DISPLACEMENT - MAG MIN: 0.00E+00 MAX: 2.07E-01
FRAME OF REF: PART

VALUE OPTION:ACTUAL

8.51D+03
7.66D+03
6.81D+03
5.96D+03
5.11D+03
4.26D+03
3.41D+03
2.56D+03
1.71D+03
8.63D+02
1.34D+01